L Number	Hits	Search Text	DB	Time stamp
1	1469	(carbon or graphite) with (nano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule)))	USPAT; US-PGPUB	2003/07/08 17:23
2	140	(suspension or colloid or sol or colloidal) same ((carbon or graphite) with (nano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule))))	USPAT; US-PGPUB	2003/07/08 16:34
3	184	(reactive or functional or functionalize or functionalized or reacting or active) with ((carbon or graphite) with (nano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule))))	USPAT; US-PGPUB	2003/07/08 16:33
4	101	(suspension or colloid or sol or colloidal) and ((reactive or functional or functionalize or functionalized or reacting or active) with ((carbon or graphite) with (nano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule)))))	USPAT; US-PGPUB	2003/07/08 17:07
5	34	(align or aligned or aligning or parallelize or parallel or parallelizing or array) same ((suspension or colloid or sol or colloidal) same ((carbon or graphite) with (nano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule)))))	USPAT; US-PGPUB	2003/07/08 17:24
6	1379	(carbon or graphite) with (swnt ornano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule)))	EPO; JPO; DERWENT	2003/07/08 17:14
7	146	(align or aligned or aligning or parallelize or parallel or parallelizing or array) and ((carbon or graphite) with (swnt ornano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule))))	EPO; JPO; DERWENT	2003/07/08 17:07
8	5	(suspension or colloid or sol or colloidal) and ((align or aligned or aligning or parallelize or parallel or parallelizing or array) and ((carbon or graphite) with (swnt ornano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule)))))	EPO; JPO; DERWENT	2003/07/08 17:10
9	766	(264/435,437,108).CCLS.	USPAT; US-PGPUB	2003/07/08 17:13
10	1	(((carbon or graphite) with (nano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule)))) or swnt) and ((264/435,437,108).CCLS.)	USPAT; US-PGPUB	2003/07/08 17:23
11	357	((carbon or graphite) with (swnt or nano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule)))).ti,ab.	USPAT; US-PGPUB	2003/07/08 17:24
12	9664	(align or aligned or aligning or parallelize or parallel or parallelizing or array) with (suspension or colloid or colloidal or sol)	USPAT; US-PGPUB	2003/07/08 17:26
13	7	(((carbon or graphite) with (swnt or nano-tube or nanotube or nano-tubing or nanotubing or nano$1tubule or (nano adj1 (tube or tubing or tubule)))).ti,ab.) and ((align or aligned or aligning or parallelize or parallel or parallelizing or array) with (suspension or colloid or colloidal or sol))	USPAT; US-PGPUB	2003/07/08 17:26

DOCUMENT-IDENTIFIER: US 20030004058 A1

TITLE: Varied morphology carbon nanotubes and method for their manufacture

---------- KWIC ---------

Summary of Invention Paragraph - BSTX (6):

[0006] A mesoporous silica **sol**-gel catalyst impregnated with iron was disclosed by Li et al. (Science, Vol. 274, (1996), 1701) for the synthesis of **aligned carbon nanotubes**. The method described by Li requires the preparation of large, flat surfaces of the iron impregnated mesoporous silica substrates with uniform distribution of pores. According to Li et al., preparation of such large area catalytic substrate is hampered by the inherent tendency to shrink, crack and shatter during their preparation. Meticulous drying procedures therefore, are required to maintain the integrity of the catalyst to obtain large area surfaces, which is critical for obtaining high density monolayer CNT **arrays**. Imperfect catalyst preparation can severely limit yields of CNT product. Also, CNT synthesis by the process of Li et al. requires a reaction temperature of 700.degree. C., which is impractical for substrates such as flat panel glass. Methods for producing an **aligned array** of linear CNTs on a substrate surface has been described in WO 99/65821 by Ren et al. in plasma conditions under an applied electrical field. Such methods however, require high vacuum conditions, which is difficult to achieve in large reactors in a commercially viable CNT manufacturing processes.

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EAST Browser - L4: (101) (suspension... | US 20030089893 A1 | Tag: S | Doc: 9/101 | Format: KWIC

File Edit View Tools Window Help

	Document ID	Title
7	US 20030101901 A1	Carbon-containing material
8	US 20030090190 A1	Field emission devices using t
9	US 20030089893 A1	Polymers containing functiona
10	US 20030086858 A1	Modification of nanotubes oxi

DOCUMENT-IDENTIFIER: US 20030089893 A1

TITLE: Polymers containing functionalized carbon nanotubes

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Abstract Paragraph - ABTX (1):

A polymer composite composed of a polymerized mixture of functionalized carbon nanotubes and monomer which chemically reacts with the functionalized nanotubes. The carbon nanotubes are functionalized by reacting with oxidizing or other chemical media through chemical reactions or physical adsorption. The reacted surface carbons of the nanotubes are further functionalized with chemical moieties that react with the surface carbons and selected monomers. The functionalized nanotubes are first dispersed in an appropriate medium such as water, alcohol or a liquefied monomer and then the mixture is polymerized. The polymerization results in polymer chains of increasing weight bound to the surface carbons of the nanotubes. The composite may consists of some polymer chains imbedded in the composite without attachment to the nanotubes. The resulting composite yields superior chemical, physical and electrical properties over polymer composites that are only physically mixed and without binding to the surface carbons of the nanotubes.

Title - TTL (1):

Polymers containing functionalized carbon nanotubes

Summary of Invention Paragraph - BSTX (7):

[0006] Methods for crosslinking matrices of carbon nanotubes are described in U.S. Pat. No. 6,203,814 and U.S. patent application Ser. No. 08/812,856. The carbon nanotubes are first functionalized, e.g., by oxidation, and then reacted with crosslinking agents to form porous crosslinked nanotube structures having novel properties.

US 20030089893A1

(19) United States

(12) **Patent Application Publication** (10) Pub. No.: US 2003/0089893 A1

Niu et al. (43) Pub. Date: May 15, 2003

(54) POLYMERS CONTAINING FUNCTIONALIZED CARBON NANOTUBES

(75) Inventors: Chunming Niu, Lexington, MA (US); Lein Ngaw, Lowell, MA (US)

Correspondence Address:
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919 Third Avenue
New York, NY 10022 (US)

(73) Assignee: Hyperion Catalysis International, Inc.

(21) Appl. No.: 10/282,685

(22) Filed: Oct. 29, 2002

Related U.S. Application Data

(60) Provisional application No. 60/336,772, filed on Oct. 29, 2001.

Publication Classification

(51) Int. Cl.^{7} H01B 1/00

(52) U.S. Cl. 252/500

(57) ABSTRACT

A polymer composite composed of a polymerized mixture of functionalized carbon nanotubes and monomer which chemically reacts with the functionalized nanotubes. The carbon nanotubes are functionalized by reacting with oxidizing or other chemical media through chemical reactions or physical adsorption. The reacted surface carbons of the nanotubes are further functionalized with chemical moieties that react with the surface carbons and selected monomers. The functionalized nanotubes are first dispersed in an appropriate medium such as water, alcohol or a liquefied monomer and then the mixture is polymerized. The polymerization results in polymer chains of increasing weight bound to the surface carbons of the nanotubes. The composite may consists of some polymer chains imbedded in the composite without attachment to the nanotubes. The resulting composite yields superior chemical, physical and electrical properties over polymer composites that are only physically mixed and without binding to the surface carbons of the nanotubes.

EAST Browser - L4: (101) (suspension | US 20030102222 A1 | Tag: S | Doc: 6/101 | Format: KWIC

File Edit View Tools Window Help

	Document ID	Title
4	US 20030108477 A1	Bulk synthesis of carbon nanot
5	US 20030106998 A1	Method for producing boron n
6	US 20030102222 A1	Deposition method for nanostr
7	US 20030101901 A1	Carbon-containing material

Detail Description Paragraph - DETX (9):

[0069] According to another alternative, the raw carbon nanotube-containing material is placed in a suitable liquid medium, such as an acidic medium, an organic solvent, or an alcohol, preferably methanol. The nanotubes are kept in suspension within the liquid medium for several hours using a high-powered ultrasonic horn, while the suspension is passed through a microporous membrane. ... be purified by oxidation in air or ... 00-700.degree. C. The impurities in the raw materials are oxidized at a faster rate than the nanotubes.

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Detail Description Paragraph - DETX (13):

[0073] An illustrative example of such a process is described as follows. Purified raw material formed as described above was found to contain approximately 90% single-walled nanotube bundles over 10 .mu.m in length and 5-50 nm in bundle diameter. Such "long" nanotube bundles are illustrated by FIG. 1A. This material was chemically etched in a solution of H.sub.2SO.sub.4 and HNO.sub.3 for 10-24 hours while being subjected to ultrasonic energy. After etching the single wall carbon nanotube bundles etched for 20 hours had an average length of 4 .mu.m and the single wall carbon nanotube bundles etched for 24 hours had an average bundle length of 0.5 .mu.m, as shown by the transmission electron microscopy images in FIGS. 1B -1C. Alternatively, the purified materials can be chemically functionalized by, for example, chemically or physically attaching chemical species to the outer surfaces of the carbon nanotubes such that they will be either soluble or form stable suspensions in certain solvents.

Detail Description Paragraph - DETX (18):

[0078] A suitable liquid medium is selected which will permit the formation of a stable suspension of the raw nanostructure material therein. According to a preferred embodiment the liquid medium comprises at least one of water, methanol, ethanol, alcohol, and dimethylformamide (DMF). According to a further preferred embodiment, the liquid medium comprises ethanol. Upon adding the raw material to the liquid medium, the mixture can optionally be subjected to ultrasonic energy or stirring using, for example, a magnetic stirrer bar, in order to facilitate the formation of a stable suspension. The amount of time that the ultrasonic energy is applied can vary, but it has been found that

US 20030102222A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2003/0102222 A1
Zhou et al. (43) Pub. Date: Jun. 5, 2003

(54) DEPOSITION METHOD FOR NANOSTRUCTURE MATERIALS

(76) Inventors: Otto Z. Zhou, Chapel Hill, NC (US); Bo Gao, Carrboro, NC (US); Guozhen Yue, Carrboro, NC (US); Soojin Oh, Carrboro, NC (US)

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(21) Appl. No.: 09/996,695

(22) Filed: Nov. 30, 2001

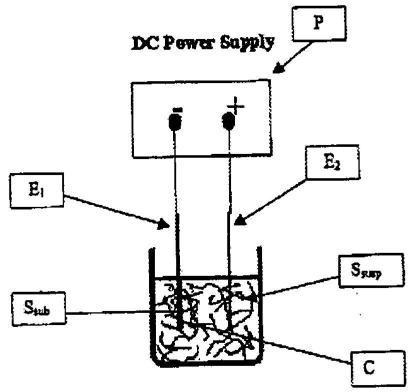
Publication Classification

(51) Int. Cl.^{7} C25D 15/00

(52) U.S. Cl. 205/109; 205/123; 205/67

(57) ABSTRACT

A method for depositing a coating of a nanostructure material onto a substrate includes: (1) forming a solution or suspension of containing the nanostructure material; (2) selectively adding "chargers" to the solution; (3) immersing electrodes in the solution, the substrate upon which the nanostructure material is to be deposited acting as one of the electrodes; (4) applying a direct and/or alternating current electrical field between the two electrodes for a certain period of time thereby causing the nanostructure materials in the solution to migrate toward and attach themselves to the substrate electrode; and (5) subsequent optional processing of the coated substrate.



SWNT Suspension

US-PAT-NO: 6531513

DOCUMENT-IDENTIFIER: US 6531513 B2

TITLE: Method of solubilizing carbon nanotubes in organic solutions

---------- KWIC ---------

Brief Summary Text - BSTX (11):

The attaching step includes directly **reacting the carbon nanotubes** with an amine having a formula RNH.sub.2 or R.sub.1 R.sub.2 NH wherein R, R.sub.1 and R.sub.2 =(CH.sub.2).sub.n CH.sub.3 where n=9-50. Alternatively, the attaching step includes directly **reacting the carbon nanotubes** with an alkylaryl amine having a formula RNH.sub.2 Or R.sub.1 R.sub.2 NH wherein R, R.sub.1 and R.sub.2 =(C.sub.6 H.sub.4)(CH.sub.2).sub.n CH.sub.3 where n=5-50.

Brief Summary Text - BSTX (22):

The nature of the noncovalent and presumably nonionic long chain amine--CNT interaction is not fully understood at this point but could involve micelle formation with the head of the amine group interacting with the wall of the CNTs leading to a **colloidal** dispersion. This interaction would allow the amine to radiate out from the CNTs and create a micelle-like particle. These particles could then form **colloidal** solutions in organic solvents. In this scenario the dissolution process of AP-CNTs takes the form of a noncovalent interaction with the long-chain amine, which is presumably similar to the interaction of ammonia with benzene. [Rodham, D. A.; Suzuki, S.; Suenram, R. D.; Lovas, F. J.; Dasgupta, S.; Goddard III, W. A.; Blake, G. A., Hydrogen Bonding in the Benzene-Ammonia Dimer. Nature 1993, 362, 735-737.

Other Reference Publication - OREF (1):

J. Liu et al. "Controlled Deposition of Individual Single-Walled **Carbon Nano-Tubes** on Chemically **Functionalized** Templates", Chemical Physics Letters 303: 125-129, Apr. 1999.*

Other Reference Publication - OREF (5):

Y. Chen et al. "Chemical Attachment of Organic **Functional** Groups to Single-Walled **Carbon Nanotube** Material", J. Mater. Res, vol. 13, No. 9, pp 2423-2431, Sep. 1998.*

US-PAT-NO: 6426134

DOCUMENT-IDENTIFIER: US 6426134 B1

TITLE: Single-wall carbon nanotube-polymer composites

---------- KWIC ---------

Brief Summary Text - BSTX (30):

Alternative precursors for preparing a polyamide component of a single wall **carbon nanotube**/polyamide composite include compounds having a carboxylic acid **functional** group and an amino **functional** group or a **functional** precursor to such a compound which compounds include 6-aminohexanoic acid, caprolactam, 5-aminopentanoic acid, 7-aminoheptanoic acid, and the like.

DERWENT-ACC-NO: 2002-425636

DERWENT-WEEK: 200336

TITLE: Composition of matter used in antennas, electromagnetic and electro-optic devices, comprises single-wall **carbon nanotube** partially coated with polymer molecule(s)

INVENTOR: COLBERT, D T; O'CONNELL, M ; SMALLEY, R E ; SMITH, K A

PRIORITY-DATA: 2001US-268269P (February 13, 2001) , 2000US-227604P (August 24,
2000) , 2001US-0935994 (August 23, 2001) , 2001US-0935493 (August 23, 2001) , 2001US-0935995 (August 23, 2001)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
EP 1313900 A2	May 28, 2003	E	000	D01F 009/12
WO 200216257 A2	February 28, 2002	E	039	C01B 000/00
US 20020046872 A1	April 25, 2002	N/A	000	H01B 017/60
US 20020048632 A1	April 25, 2002	N/A	000	D01F 009/12
US 20020068170 A1	June 6, 2002	N/A	000	B32B 005/16
AU 200186655 A	March 4, 2002	N/A	000	C01B 000/00

INT-CL (IPC): B05D001/28, B05D003/02 , B05D007/22 , B32B005/16 , B32B009/00 , B67B007/00 , C01B000/00 , C01B031/00 , C09C001/56 , D01F009/12 , D02G003/00 , G01F011/00 , H01B017/60

ABSTRACTED-PUB-NO: US20020046872A

BASIC-ABSTRACT:

NOVELTY - The composition of matter comprises single-wall **carbon nanotube (SWNT)** partially coated with polymer molecule(s).

DETAILED DESCRIPTION - INDEPENDENT CLAIMS are also included for the

following:

(i) electrically-conducting composite, comprises **aligned** polymer-coated aggregate of uncoated single-wall **carbon nanotubes (SWNTs**);

(ii) formation of conducting rod composite material, involves coating several individual SWNTs (which are substantially electrically isolated from one another) with polymer molecule(s);

(iii) association of polymer with side walls of several individual **SWNTs,** involves dispersing purified **SWNT** material (free of amorphous **carbon**) in polymer by high-shear mixing and ultrasonication, followed by adding a salt (e.g. sodium chloride) to resulting solution. The solution is then centrifuged, decanted and SWNT material is re-dispersed in water by mechanical agitation, and material is passed through filter;

(iv) formation of polymer-coated SWNT, involves dispersing SWNTs and polymer in solvent by mixing, sonication and/or heating;

(v) formation of polymer-coated aggregate of SWNTs, involves dispersing aggregate of SWNTs and polymer in solvent by mixing, sonication and heating;

(vi) dielectric material comprising several polymer-coated SWNTs;

(vii) structure comprising dielectric material, like capacitor dielectrics, circuit board materials, electromagnetic radiation absorbing materials, optoelectronic materials, antenna **arrays,** material for suspending antennas and waveguide materials;

(viii) structure comprising composition of matter;

(ix) material comprising aggregate or plurality of SWNTs, like electro-mechanical or opto-mechanical material whose electromagnetic wave properties are modified by applying electrical or magnetic field;

(x) fluid comprising polymer-coated SWNTs, has viscosity which is controlled by applying electric field and/or magnetic field;

(xi) film comprising polymer-coated SWNTs; and

(xii) fiber comprising polymer-coated SWNTs.

USE - For use in antenna, electromagnetic and electro-optic devices and

high-toughness materials. The material comprising polymer-coated SWNT is used for capacitor dielectrics, circuit board materials, waveguide materials, optical index-matching materials, materials that absorb electromagnetic radiation, materials that re-direct electromagnetic radiation, optoeloectronic materials, antenna **arrays** and materials for suspending antennas. The material is also used as supports for catalysts used in industrial and chemical devices and processes like hydrogenation, reforming and wrapping. SWNT-conducting-rod composite material is used in optical applications like lenses and reflectors.

ADVANTAGE - The composition of matter has novel and useful electrical, mechanical and chemical properties that are distinct from conventional SWNT-containing materials. The composition of matter provides SWNT conducting-rod composite, and also enables creation of high-concentration **suspensions** of SWNTs and compatibility of SWNTs with polymeric matrices in composite materials. The solubility and compatibility, in turn, enables chemical manipulation of nanotube and production of composite fibers, films and solids comprising SWNTs. The novel SWNT-containing materials have novel electronic and/or electromagnetic properties derived from electrical conductivity and high electrical polarizability of SWNTs. SWNT conducting-rod composite materials comprising SWNT in a solid matrix, are electrostrictive, magnetostrictive, Chemie-strictive which change their physical dimensions in response to electric or magnetic fields, and chemisorption of atoms and molecules on their surfaces.

ABSTRACTED-PUB-NO: US20020048632A

EQUIVALENT-ABSTRACTS:

NOVELTY - The composition of matter comprises single-wall **carbon nanotube (SWNT)** partially coated with polymer molecule(s).

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polymer by high-shear mixing and ultrasonication, followed by adding a salt (e.g. sodium chloride) to resulting solution. The solution is then centrifuged, decanted and SWNT material is re-dispersed in water by mechanical agitation, and material is passed through filter;

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US20020068170A

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(iii) association of polymer with side walls of several individual **SWNTs,** involves dispersing purified **SWNT** material (free of amorphous **carbon**) in polymer by high-shear mixing and ultrasonication, followed by adding a salt (e.g. sodium chloride) to resulting solution. The solution is then centrifuged, decanted and SWNT material is re-dispersed in water by mechanical agitation, and material is passed through filter;

(iv) formation of polymer-coated SWNT, involves dispersing SWNTs and polymer in solvent by mixing, sonication and/or heating;

(v) formation of polymer-coated aggregate of SWNTs, involves dispersing aggregate of SWNTs and polymer in solvent by mixing, sonication and heating;

(vi) dielectric material comprising several polymer-coated SWNTs;

(vii) structure comprising dielectric material, like capacitor dielectrics, circuit board materials, electromagnetic radiation absorbing materials, optoelectronic materials, antenna **arrays,** material for suspending antennas and waveguide materials;

(viii) structure comprising composition of matter;

(ix) material comprising aggregate or plurality of SWNTs, like electro-mechanical or opto-mechanical material whose electromagnetic wave properties are modified by applying electrical or magnetic field;

(x) fluid comprising polymer-coated SWNTs, has viscosity which is controlled by applying electric field and/or magnetic field;

(xi) film comprising polymer-coated SWNTs; and

(xii) fiber comprising polymer-coated SWNTs.

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WO 200216257A

---------- KWIC ---------

Basic Abstract Text - ABTX (1):
NOVELTY - The composition of matter comprises single-wall **carbon nanotube (SWNT)** partially coated with polymer molecule(s).

Basic Abstract Text - ABTX (3):
(i) electrically-conducting composite, comprises **aligned** polymer-coated aggregate of uncoated single-wall **carbon nanotubes (SWNTs)**;

Basic Abstract Text - ABTX (5):
(iii) association of polymer with side walls of several individual **SWNTs,** involves dispersing purified **SWNT** material (free of amorphous **carbon**) in polymer by high-shear mixing and ultrasonication, followed by adding a salt (e.g. sodium chloride) to resulting solution. The solution is then centrifuged, decanted and SWNT material is re-dispersed in water by mechanical agitation, and material is passed through filter;

Basic Abstract Text - ABTX (9):
(vii) structure comprising dielectric material, like capacitor dielectrics, circuit board materials, electromagnetic radiation absorbing materials, optoelectronic materials, antenna **arrays,** material for suspending antennas and waveguide materials;

Basic Abstract Text - ABTX (15):
USE - For use in antenna, electromagnetic and electro-optic devices and high-toughness materials. The material comprising polymer-coated SWNT is used for capacitor dielectrics, circuit board materials, waveguide materials, optical index-matching materials, materials that absorb electromagnetic radiation, materials that re-direct electromagnetic radiation, optoeloectronic materials, antenna **arrays** and materials for suspending antennas. The material is also used as supports for catalysts used in industrial and chemical devices and processes like hydrogenation, reforming and wrapping. SWNT-conducting-rod composite material is used in optical applications like lenses and reflectors.

Basic Abstract Text - ABTX (16):
ADVANTAGE - The composition of matter has novel and useful electrical, mechanical and chemical properties that are distinct from conventional SWNT-containing materials. The composition of matter provides SWNT conducting-rod composite, and also enables creation of high-concentration **suspensions** of SWNTs and compatibility of SWNTs with polymeric matrices in composite materials. The solubility and compatibility, in turn, enables chemical manipulation of nanotube and production of composite fibers, films and solids comprising SWNTs. The novel SWNT-containing materials have novel electronic and/or electromagnetic properties derived from electrical conductivity and high electrical polarizability of SWNTs. SWNT conducting-rod composite materials comprising SWNT in a solid matrix, are electrostrictive, magnetostrictive, Chemie-strictive which change their physical dimensions in response to electric or magnetic fields, and chemisorption of atoms and

molecules on their surfaces.

Title - TIX (1):
Composition of matter used in antennas, electromagnetic and electro-optic devices, comprises single-wall **carbon nanotube** partially coated with polymer molecule(s)

Equivalent Abstract Text - ABEQ (1):
NOVELTY - The composition of matter comprises single-wall **carbon nanotube (SWNT)** partially coated with polymer molecule(s).

Equivalent Abstract Text - ABEQ (3):
(i) electrically-conducting composite, comprises **aligned** polymer-coated aggregate of uncoated single-wall **carbon nanotubes (SWNTs)**;

Equivalent Abstract Text - ABEQ (5):
(iii) association of polymer with side walls of several individual **SWNTs,** involves dispersing purified **SWNT** material (free of amorphous **carbon**) in polymer by high-shear mixing and ultrasonication, followed by adding a salt (e.g. sodium chloride) to resulting solution. The solution is then centrifuged, decanted and SWNT material is re-dispersed in water by mechanical agitation, and material is passed through filter;

Equivalent Abstract Text - ABEQ (9):
(vii) structure comprising dielectric material, like capacitor dielectrics, circuit board materials, electromagnetic radiation absorbing materials, optoelectronic materials, antenna **arrays,** material for suspending antennas and waveguide materials;

Equivalent Abstract Text - ABEQ (15):
USE - For use in antenna, electromagnetic and electro-optic devices and high-toughness materials. The material comprising polymer-coated SWNT is used for capacitor dielectrics, circuit board materials, waveguide materials, optical index-matching materials, materials that absorb electromagnetic radiation, materials that re-direct electromagnetic radiation, optoeloectronic materials, antenna **arrays** and materials for suspending antennas. The material is also used as supports for catalysts used in industrial and chemical devices

and processes like hydrogenation, reforming and wrapping. SWNT-conducting-rod composite material is used in optical applications like lenses and reflectors.

Equivalent Abstract Text - ABEQ (16):

ADVANTAGE - The composition of matter has novel and useful electrical, mechanical and chemical properties that are distinct from conventional SWNT-containing materials. The composition of matter provides SWNT conducting-rod composite, and also enables creation of high-concentration **suspensions** of SWNTs and compatibility of SWNTs with polymeric matrices in composite materials. The solubility and compatibility, in turn, enables chemical manipulation of nanotube and production of composite fibers, films and solids comprising SWNTs. The novel SWNT-containing materials have novel electronic and/or electromagnetic properties derived from electrical conductivity and high electrical polarizability of SWNTs. SWNT conducting-rod composite materials comprising SWNT in a solid matrix, are electrostrictive, magnetostrictive, Chemie-strictive which change their physical dimensions in response to electric or magnetic fields, and chemisorption of atoms and molecules on their surfaces.

Equivalent Abstract Text - ABEQ (17):

NOVELTY - The composition of matter comprises single-wall **carbon nanotube (SWNT)** partially coated with polymer molecule(s).

Equivalent Abstract Text - ABEQ (19):

(i) electrically-conducting composite, comprises **aligned** polymer-coated aggregate of uncoated single-wall **carbon nanotubes (SWNTs)**;

Equivalent Abstract Text - ABEQ (21):

(iii) association of polymer with side walls of several individual **SWNTs,** involves dispersing purified **SWNT** material (free of amorphous **carbon**) in polymer by high-shear mixing and ultrasonication, followed by adding a salt (e.g. sodium chloride) to resulting solution. The solution is then centrifuged, decanted and SWNT material is re-dispersed in water by mechanical agitation, and material is passed through filter;

Equivalent Abstract Text - ABEQ (25):

(vii) structure comprising dielectric material, like capacitor dielectrics, circuit board materials, electromagnetic radiation absorbing materials,

optoelectronic materials, antenna **arrays,** material for suspending antennas and waveguide materials;

Equivalent Abstract Text - ABEQ (31):
USE - For use in antenna, electromagnetic and electro-optic devices and high-toughness materials. The material comprising polymer-coated SWNT is used for capacitor dielectrics, circuit board materials, waveguide materials, optical index-matching materials, materials that absorb electromagnetic radiation, materials that re-direct electromagnetic radiation, optoeloectronic materials, antenna **arrays** and materials for suspending antennas. The material is also used as supports for catalysts used in industrial and chemical devices and processes like hydrogenation, reforming and wrapping. SWNT-conducting-rod composite material is used in optical applications like lenses and reflectors.

Equivalent Abstract Text - ABEQ (32):
ADVANTAGE - The composition of matter has novel and useful electrical, mechanical and chemical properties that are distinct from conventional SWNT-containing materials. The composition of matter provides SWNT conducting-rod composite, and also enables creation of high-concentration **suspensions** of SWNTs and compatibility of SWNTs with polymeric matrices in composite materials. The solubility and compatibility, in turn, enables chemical manipulation of nanotube and production of composite fibers, films and solids comprising SWNTs. The novel SWNT-containing materials have novel electronic and/or electromagnetic properties derived from electrical conductivity and high electrical polarizability of SWNTs. SWNT conducting-rod composite materials comprising SWNT in a solid matrix, are electrostrictive, magnetostrictive, Chemie-strictive which change their physical dimensions in response to electric or magnetic fields, and chemisorption of atoms and molecules on their surfaces.

Equivalent Abstract Text - ABEQ (33):
NOVELTY - The composition of matter comprises single-wall **carbon nanotube (SWNT)** partially coated with polymer molecule(s).

Equivalent Abstract Text - ABEQ (35):
(i) electrically-conducting composite, comprises **aligned** polymer-coated aggregate of uncoated single-wall **carbon nanotubes (SWNTs)**;

Equivalent Abstract Text - ABEQ (37):

(iii) association of polymer with side walls of several individual **SWNTs,** involves dispersing purified **SWNT** material (free of amorphous **carbon**) in polymer by high-shear mixing and ultrasonication, followed by adding a salt (e.g. sodium chloride) to resulting solution. The solution is then centrifuged, decanted and SWNT material is re-dispersed in water by mechanical agitation, and material is passed through filter;

Equivalent Abstract Text - ABEQ (41):

(vii) structure comprising dielectric material, like capacitor dielectrics, circuit board materials, electromagnetic radiation absorbing materials, optoelectronic materials, antenna **arrays,** material for suspending antennas and waveguide materials;

Equivalent Abstract Text - ABEQ (47):

USE - For use in antenna, electromagnetic and electro-optic devices and high-toughness materials. The material comprising polymer-coated SWNT is used for capacitor dielectrics, circuit board materials, waveguide materials, optical index-matching materials, materials that absorb electromagnetic radiation, materials that re-direct electromagnetic radiation, optoeloectronic materials, antenna **arrays** and materials for suspending antennas. The material is also used as supports for catalysts used in industrial and chemical devices and processes like hydrogenation, reforming and wrapping. SWNT-conducting-rod composite material is used in optical applications like lenses and reflectors.

Equivalent Abstract Text - ABEQ (48):

ADVANTAGE - The composition of matter has novel and useful electrical, mechanical and chemical properties that are distinct from conventional SWNT-containing materials. The composition of matter provides SWNT conducting-rod composite, and also enables creation of high-concentration **suspensions** of SWNTs and compatibility of SWNTs with polymeric matrices in composite materials. The solubility and compatibility, in turn, enables chemical manipulation of nanotube and production of composite fibers, films and solids comprising SWNTs. The novel SWNT-containing materials have novel electronic and/or electromagnetic properties derived from electrical conductivity and high electrical polarizability of SWNTs. SWNT conducting-rod composite materials comprising SWNT in a solid matrix, are electrostrictive, magnetostrictive, Chemie-strictive which change their physical dimensions in response to electric or magnetic fields, and chemisorption of atoms and molecules on their surfaces.

DOCUMENT-IDENTIFIER: US 20020185770 A1

TITLE: Method for aligning **carbon nanotubes** for composites

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Abstract Paragraph - ABTX (1):

A reinforced polymer is formed by combining a quantity of nano-fibers, preferably **carbon nanotubes,** with powders of the polymer. The mixture is heated to cause the polymer to fuse to the fibers, forming a feedstock. The feedstock is heated and forced through a die that has channels that change in direction a number of times. Each change in direction results in a high shear stress applied to the feedstock. The shear stress causes the twisted ropes of **carbon nanotubes** to elongate and align with each other. Rather than a die, sheet rollers may be employed to apply the shear stress.

Current US Classification, US Primary Class/Subclass - CCPR (1):

264/108

Title - TTL (1):

Method for aligning **carbon nanotubes** for composites

Summary of Invention Paragraph - BSTX (2):

[0002] This invention relates in general to a method of producing a polymer reinforced with high aspect ratio nano-fibers, particularly **carbon nanotubes,** that are collimated.

Summary of Invention Paragraph - BSTX (4):

[0003] **Carbon nanotubes** are molecular scale fibers, on the order of size of DNA, that are composed entirely of **carbon** atoms arranged in a linked hexagonal pattern. In one form, the nanotubes have multiple walls as represented by a rolled-up sheet of paper or by sheets of paper formed into a tubular shape. In the preferred form, the **nanotubes** resemble a single sheet hollow tube with a wall thickness of one layer of **carbon** atoms. **Carbon nanotubes,** particularly

single-wall **nanotubes,** possess the greatest strength and stiffness of any material that has ever been produced or that can be produced. The strength and stiffness is of enormous potential benefit to the creation of lightweight composite structures made of polymers reinforced with such nanotubes.

Summary of Invention Paragraph - BSTX (5):

[0004] Limited availability of nanotubes has slowed composite development. However, even when sufficient lab-scale quantities have been available, several characteristics of **carbon nanotubes** have prevented combining polymers with adequate amounts of **nanotubes** to achieve any structural benefits. One of these characteristics is small size. The lengths of tubes have been in the order of 100-200 nanometers and up to one micron, with diameters less than five nanometers. Consequently, there is a very high aspect ratio between the length to the diameter. A greater limitation has resulted from an intrinsic characteristic of **carbon nanotubes**. The nanotubes clump together, creating rope-like strands that are entwined. These clumping or roping forces are so strong that separation and collimation of the nanotubes has been difficult. Furthermore, the characteristics of the nanotubes are such that polymers into which they are stirred become highly viscous very quickly. This thickening effect causes stiffening of the mixture to a point where no further additions of nanotubes can occur. The limit is reached at concentrations far less than desired to impart attractive structural characteristics to the resulting composite. To help deal with these phenomena, chemical treatments are being developed to impart specific chemical functionality to the nanotubes.

Summary of Invention Paragraph - BSTX (8):

[0006] In this invention, a process of aligning **carbon nanotubes,** nano-fibers or other nano-scale fibers (referred to herein collectively as "nano-fibers"), comprises combining a quantity of nanofibers with a polymer to create a billet or feedstock. Then, the feedstock is heated and high shear forces are applied to the feedstock, the high shear forces causing alignment and collimation of the nano-fibers.

Detail Description Paragraph - DETX (2):

[0020] Referring to FIG. 1, vessel 11 represents a conventional mixing vessel for mixing finely divided powders. Vessel 11 has nano-fibers 13 therein, which are preferably single or multi-wall **carbon nanotubes**. Vessel 11 also has powders of a polymer 15, which may be either a thermoplastic or a thermosetting polymer. Examples of thermoplastic polymers are polyetherimide, nylon, and propylene. Examples of thermosetting polymers are epoxy, cyanate

ester, or bismaleimide. If the resulting reinforced polymer is to be in the form of a fiber or filament, preferably thermoplastic polymers are used. Thermosetting polymers may be more suitable for forming sheets of nano-fiber reinforced polymer.

Detail Description Paragraph - DETX (18):

[0036] The invention has significant improvements. The resulting polymer is reinforced greatly by the nano-fibers. The methods employed do not require a chemical treatment but chemical treating could be employed in addition, if desired. The high shear flow conditions mechanically force alignment of the **carbon nanotubes**.

Claims Text - CLTX (25):

25. The material of claim 23, wherein the nano-fibers comprise **carbon nanotubes**.

DERWENT-ACC-NO: 2001-451330

DERWENT-WEEK: 200325

TITLE: **Aligning** single-wall **carbon nano-tubes** for making e.g. high strength fibers and cables, comprises subjecting to magnetic or electric field

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JP 2003512286 W	April 2, 2003	N/A	070	C01B 031/02
WO 200130694 A1	May 3, 2001	E	073	C01B 031/02
AU 200122483 A	May 8, 2001	N/A	000	C01B 031/02
EP 1226093 A2	July 31, 2002	E	000	C01B 031/02
CN 1359352 A	July 17, 2002	N/A	000	C01B 031/02
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INT-CL (IPC): B82B003/00, C01B031/02

ABSTRACTED-PUB-NO: WO 200130694A

BASIC-ABSTRACT:

NOVELTY - Single-wall **carbon nanotubes (SWNT) are aligned** by subjecting them to a magnetic field or an electric field.

DETAILED DESCRIPTION - INDEPENDENT CLAIMS are also included for the following:

(A) a method of assembling field**-aligned** SWNT into three-dimensional structure in which the tubes are **parallel** to each other;

(B) a material comprising **aligned** single-wall nanotubes;

(C) a method of creating objects and materials from field**-aligned** tubes in solution or **suspension,** comprising modifying the solvent strength of the nano-tube solution to precipitate tubes;

(D) a method of forming a membrane of **aligned** SWNT, comprising field**-aligning** end-derivatized SWNT, and diffusing and chemically attaching the SWNT to a substrate oriented perpendicular to the field-alignment direction;

(E) an apparatus for forming **arrays of aligned** SWNT, comprising a tank, a positive electrode disposed in the tank, a negative electrode disposed in the tank, a filter disposed in the tank near the positive electrode, SWNT suspended in a solution within a tank, and a source of magnetic field for **aligning** the SWNT; and

(F) a method of post-processing macroscopic ordered nano-tube assemblies to selectively enhance material properties.

USE - Used for **aligning** single-wall **carbon nano-tubes**. It can be employed to produce macroscopic assembly of single-wall **carbon nanotubes,** which can be utilized for electrical, chemical, mechanical, and biological applications. It can be utilized to form materials that can be used for high strength fibers and cables, electrical transmission lines, structural materials, impact-resistant materials, armor, structural laminates having layers with different tube orientations, pressure vessel exteriors and reinforcement, thermal management materials (e.g., heat-transporting materials), heat-resistant materials, airframe (components) for aircraft and missiles, vehicle bodies, ship hulls, chemically inert materials, electrochemical electrodes, battery electrodes, catalyst supports, biologically-inert materials, sensors, and materials that absorb, support and dispense moieties that intercalate, and transducer elements.

ADVANTAGE - The method allows the single-wall **carbon nano-tubes to be aligned** in the same direction, thus capable of forming macroscopic ordered assembly of **carbon nanotubes** having remarkable physical, electrical, and chemical properties.

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Basic Abstract Text - ABTX (1):
NOVELTY - Single-wall **carbon nanotubes (SWNT) are aligned** by subjecting them to a magnetic field or an electric field.

Basic Abstract Text - ABTX (3):
(A) a method of assembling field-**aligned** SWNT into three-dimensional structure in which the tubes are **parallel** to each other;

Basic Abstract Text - ABTX (4):
(B) a material comprising **aligned** single-wall nanotubes;

Basic Abstract Text - ABTX (5):
(C) a method of creating objects and materials from field-**aligned** tubes in solution or **suspension,** comprising modifying the solvent strength of the nano-tube solution to precipitate tubes;

Basic Abstract Text - ABTX (6):
(D) a method of forming a membrane of **aligned** SWNT, comprising field-**aligning** end-derivatized SWNT, and diffusing and chemically attaching the SWNT to a substrate oriented perpendicular to the field-alignment direction;

Basic Abstract Text - ABTX (7):
(E) an apparatus for forming **arrays of aligned** SWNT, comprising a tank, a positive electrode disposed in the tank, a negative electrode disposed in the tank, a filter disposed in the tank near the positive electrode, SWNT suspended in a solution within a tank, and a source of magnetic field for **aligning** the SWNT; and

Basic Abstract Text - ABTX (9):
USE - Used for **aligning** single-wall **carbon nano-tubes**. It can be employed to produce macroscopic assembly of single-wall **carbon nanotubes,** which can be utilized for electrical, chemical, mechanical, and biological applications. It can be utilized to form materials that can be used for high strength fibers and cables, electrical transmission lines, structural materials, impact-resistant materials, armor, structural laminates having layers with different tube

orientations, pressure vessel exteriors and reinforcement, thermal management materials (e.g., heat-transporting materials), heat-resistant materials, airframe (components) for aircraft and missiles, vehicle bodies, ship hulls, chemically inert materials, electrochemical electrodes, battery electrodes, catalyst supports, biologically-inert materials, sensors, and materials that absorb, support and dispense moieties that intercalate, and transducer elements.

Basic Abstract Text - ABTX (10):
ADVANTAGE - The method allows the single-wall **carbon nano-tubes to be aligned** in the same direction, thus capable of forming macroscopic ordered assembly of **carbon nanotubes** having remarkable physical, electrical, and chemical properties.

Title - TIX (1):
Aligning single-wall **carbon nano-tubes** for making e.g. high strength fibers and cables, comprises subjecting to magnetic or electric field

Standard Title Terms - TTX (1):
ALIGN SINGLE WALL **CARBON NANO TUBE** HIGH STRENGTH FIBRE CABLE COMPRISE
SUBJECT MAGNETIC ELECTRIC FIELD